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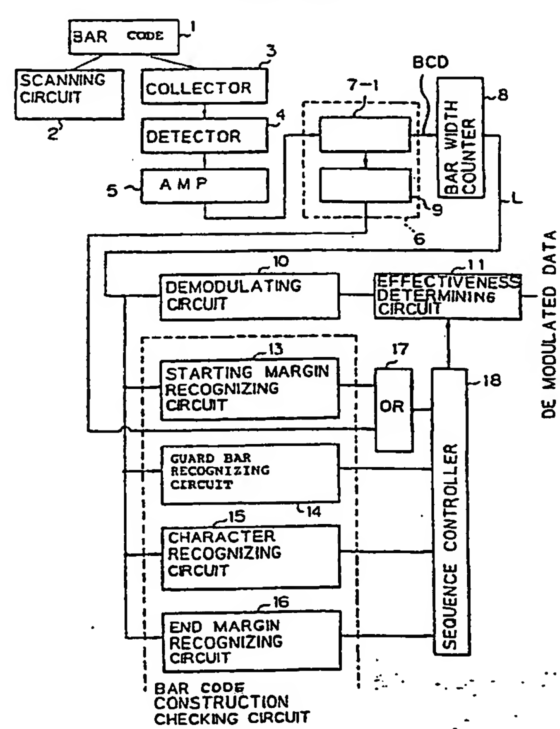
(54) Bar code readers.

(57) A bar code reading system produces a binary signal from an analog signal containing a bar code signal, and derives from the binary signal appropriate bar code data. The bar code reading system comprises an amplitude increase detector (9) for detecting when the amplitude of the analog signal changes steeply, and a sequence controller (18) for controlling an output of a demodulator (10) that demodulates the binary signal to produce the bar code data. When the amplitude increase detector (9) provides a detected signal, indicative of a steep increase in the analog signal, the sequence controller (18) carries out its controlling task as if the bar code has a normal white margin even if the white margin produces noise.

Such a system can correctly recognize the start of the bar code irrespective of noise and can enable a lower limit threshold level, below which the analog signal is effectively ignored, to be lowered, thereby improving dynamic range.

Fig. 2A



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BAR CODE READERS

The present invention relates to bar code readers.

In recent years, bar code readers are widely used with POS terminals as means for merchandise management.

Figure 5 shows a previously-considered bar code reader. In the figure, numeral 130 denotes a signal input portion, 131 an amplifier, 132 a differential circuit, 133 a low-pass filter, 134 an amplifier, 135 an integrating circuit, 136 a comparator, 137 a resistor, 138 an amplifier, 139 a peak holding circuit, 140 a DC level circuit, 141 a discharging circuit, 142 a voltage dividing circuit, 143 reversing amplifier, 144 and 145 comparators, 146 and 147 delay circuits, 148 and 149 AND circuits, 150 an inverter, 151 a flip-flop, and 152 a lower limiter.

The integrating circuit 135, comparator 136, and resistor 137 form a comparing portion 110. The peak holding circuit 139, DC level circuit 140, discharging circuit 141, voltage dividing circuit 142, reversing amplifier 143, and lower limiter 152 from a slice level creating circuit 111. The comparators 144 and 145 and delay circuits 146 and 147 form a delay gate signal output portion 112. The AND circuits 148 ana 149 form a signal output portion 113.

Operation of the bar code reader of Fig. 5 will be explained.

The signal input portion 130 receives a bar code read signal. The amplifier 131 amplifies the signal, and the differential circuit 132 differentiates the amplified signal. The low-pass filter 133 removes high-frequency noise from the differentiated signal, and the amplifier 138 amplifies an output of the low-pass filter 133. The peak holding circuit 139 and DC level circuit 140 receives an output of the amplifier 138. The discharging circuit 141 receives outputs of the circuits 139 and 140. An output of the discharging circuit 141 passes through the lower limiter 152, voltage dividing circuit 142, and reversing amplifier 143, thereby providing positive and negative slice levels. The DC level circuit 140 provides an intermediate level of the slice levels.

The comparator 144 receives the positive slice level from the reversing amplifier 143, and the comparator 145 receives the negative slice level from the voltage dividing circuit 142. The delay circuits 146 and 147 adjust outputs of the comparators 144 and 145, respectively, with respect to a delay time existing in the integrating circuit 135, and provide outputs to the AND circuits 148 and 149, respectively.

The low-pass filter 133 also provides its output to the amplifier 134. The amplifier 134 provides an output to the comparator 136 and to the integrating circuit 135. The integrating circuit 135 delays the input signal for a predetermined time and provides the delayed signal to the comparator 136.

According to the outputs of the amplifier 134 and integrating circuit 135, the comparator 136 provides an output to the AND circuit 148 and to the AND circuit 149 through the inverter 150.

Outputs of the AND circuits 148 and 149 are edge signals that indicate the start and the end af a black bar of the bar code, respectively. By monitoring output signals of the flip-flop 151, it is possible to detect the widths and numbers of black and white bars of the bar code and decode the bar code.

An operation of reading black and white bars of a bar code, carried out by the Figure 5 reader, will be explained with reference to Fig. 6.

Figure 6(A) shows a bar code comprising black bars B1 and B2 and a white bar defined between the black bars. Figure 6(B) shows a signal read from the bar code of Fig. 6(A). The differential circuit 132 of Fig. 5 differentiates the read signal and provides a signal indicated with a continuous line in Fig. 6(C). The integrating circuit 135 of Fig. 5 integrates the differentiated signal and provides a signal indicated with a dotted line in Fig. 6(C). The integrating circuit 135 has a small time constant and provides a delay function.

The comparator 136 of Fig. S compares the differentiated signal with the integrated signal, and when the signal from the integrating circuit 135 becomes larger than the other, provides a high (H) level signal as shown in Fig. 6(D).

The comparators 144 and 145 compare the differentiated signal indicated with the continuous line in Fig. 6(C) with a positive slice level Th1 and negative slice level Th2, and provide gate signals shown in Figs. 6(E) and 6(F), respectively.

The AND circuits 148 and 149 receive the gate signals and the signal of Fig. 6(D) provided by the comparing portion 110, and provide signals shown in Figs. (6(G) and 6(H), respectively. These signals represent the black and white bars of the bar code as shown in Fig. 6(I), and may set and reset the flip-flops 151 of Fig. 5, thereby providing a signal representing the widths of the black and white bars.

The bar code is sometimes printed on a cylindrical object. In this case, the bar code may provide, when read, weak signals depending on reading angles. To process the weak signals, the bar code reader must have a large dynamic range. Namely, it must have small positive and negative slice levels.

According to standards, the bar code has mar-

gins at the start and the end thereof to prevent erroneous reading. Each of the margins comprises a white bar having a predetermined width.

The bar code reader has a detector that detects reflected light from a medium. The bar code reader amplifies the detected light and provides a binary signal. Thereafter, as shown in Fig. 7, a bar code construction checking portion 160 checks a format of the bar code, and a demodulating portion 166 demodulates the bar code into definite numerals according to a recognition logic.

The bar code construction checking portion 160 comprises a start margin recognizing portion 161, a guard bar recognizing portion 162, a character recognizing portion 163, an end margin recognizing portion 164, etc. The start margin recognizing portion 161 checks to see whether or not a prescribed white margin exists at the left side of the bar code. The guard bar recognizing portion 162 checks to see whether or not prescribed guard bars exist on each side and the center of the bar code. The character recognizing portion 163 checks to see that each character comprises two white bars and two black bars and that there are seven character modules. The end margin recognizing portion 164 checks to see whether or not a prescribed white margin exists at the right side of the bar code.

An amplifying portion 170 of Fig. 7 (corresponding to the amplifier 131, differential circuit 132, low-pass filter 133, etc., of Fig. 5) provides an input signal to a binary circuit 171 (corresponding to the comparing portion 110, slice level creating circuit 111, gate signal output portion 112, signal output portion 113, flip-flop 151, etc., of Fig. 5) A bar width counter 173 measures the widths of white and black bars according to an output of the binary circuit 171, and provides the measured result to the demodulating portion 166 and bar code construction checking portion 160.

The demodulating portion 166 demodulates the output of the bar width counter 173 into characters, i.e., concrete numerals. The bar code construction checking portion 160 checks the bar code. If the bar code is normal, a sequence controller 165 sends an effective signal to an effectiveness determining section 167. In response to the effective signal, the effectiveness determining section 167 passes the numerals decoded by the demodulating portion 166, as demodulated data.

If the read bar code including the margins is not correctly converted into binary data, it is impossible to read the bar code.

A laser bar code reader has a deep reading depth and a large dynamic range for reflected light.

A margin of a bar code is printed white so that it may basically cause no change in the quantity of reflected light. When a laser beam for scanning the bar code is thin and the quantity of reflected light is large, the margin may produce relatively large noise due to very small irregularities on the surface of a sheet where the bar code is printed.

To prevent the margin from providing erroneous binary data due to the noise, the bar code reader described above employs the lower limiter 152 of Fig. 5 and the lower limiter 172 of Fig. 7. These limiters prevent a slice level from dropping below a predetermined value, thereby preventing noise below the predetermined level from providing binary data.

This predetermined level is required not to be too small. This raises a problem that a weak signal generated from a small quantity of reflected light and having a signal level below the predetermined level cannot be converted into binary data. In this case, it is impossible to read the bar code.

It is desirable to provide a bar code reading system employing high-speed scanning means for reading a bar code formed on the surface of a moving object. Such a system should desirably be capable of correctly reading a bar code and converting it into binary data in conditions in which the level of reflected light is weak and irregularities on the surface of the object on which the bar code is printed produce noise.

A bar code reading apparatus embodying the present invention comprises a scanning portion, a collector for collecting light reflected from a bar code, a binary circuit for providing binary data according to an analog signal contained in the collected light, a bar width counter for computing the widths of bars of the bar code according to an output of the binary circuit, a demodulating portion for generating predetermined information according to values provided by the bar width counter, a bar code construction checking portion for checking the construction of predetermined parts of the bar code according to the values provided by the bar width counter, and a sequence controller for controlling the bar code construction checking portion, judging, only when the bar code has a predetermined construction, that output data provided by the demodulating portion is effective, and letting the data of the demodulating portion go out. The bar code reading apparatus also includes an amplitude increase detecting means for detecting when the amplitude of the analog signal steeply changes. When the amplitude increase detecting means provides a detected signal, the sequence controller acts as if there were a normal white margin in the bar code, even if at least a start margin of the bar code produce noise.

Reference will now be made, by way of example, to the accompanying drawings in which:

Fig. 1 is a block diagram of parts of circuitry in a bar code reader embodying the present inven-

tion;

Fig. 2A is a general block diagram of circuitry in a first bar code reader embodying the invention;

Fig. 2B is a block circuit diagram corresponding to Fig. 2A in which parts of the Fig. 2A circuitry are shown in greater detail;

Fig. 3 is a waveform diagram illustrating operation of the Fig. 2A reader;

Figs. 4A to 4C together show a circuit diagram of circuitry in a second bar code reader embodying the present invention;

Figs 5A and 5B show a block diagram of signal processing circuitry in a bar code reader not embodying the invention;

Fig. 6 is a waveform diagram illustrating operation of the circuitry of Fig. 5; and

Fig. 7 is a general block diagram of circuitry in the Fig. 5 reader.

A bar code reading system embodying the present invention can read at a high speed a bar code printed on a object that is itself moving at high speed. The diameter of a laser beam emitted by such a bar code reading system should preferably be thin, and the quantity of reflected light of the laser beam collected by a collector may be small. In obtaining binary data from the collected laser beam under these conditions, noise easily occurs.

Under these conditions, it is not preferable to fix a limiter level for providing the binary data because noise levels may frequently exceed the fixed limiter level. However, a means (such as the slice level creating circuit 111 of Fig. 5) for changing the limiter level in response to the quantity of input light may also not always be preferable. If the limiter level is set low for a small quantity of light, for example when scanning a white bar of a bar code, stains and dirt on the white bar may produce an output that exceeds the limiter level, and such an output may provide erroneous information that a black bar exists.

A bar code reader embodying the invention utilizes the fact that the detection level of a correct black bar of a bar code is much larger than that of a white bar of the bar code. When scanning across a white bar, imperfections thereon may gives rise to an erroneous "black bar detected" signal, but thereafter a correct black bar following the white bar normally gives rise to a steep increase in the level of the detected signal. If such an increase exceeds a predetermined value a bar code reader embodying the present invention judges that there is a black bar at the position where the steep increase in the signal level has occurred and that the signal detected before the steep increase is noise. The reader then effectively ignores the noise and indicates that the white bar is continuous across its width.

Namely, if there is a steep increase in a detected signal level, the reader effectively ignores a noise occurring state before the steep increase.

More precisely, in reading start margin, guard bar, characters, guard bar, and end margin of a bar code in this order, bar code readers are liable to mistakenly recognize stains and dust on the start margin as part of the guard bar. A reader embodying the invention, however, judges that an erroneous signal produced by the stains and dust on the start margin is noise and that the start margin is continuous, provided that a correct guard bar is detected after the erroneous signal, i.e. a steep increase in a detected signal level is detected after detection of the erroneous signal. Namely the reader determines that the signal that has caused the steep increase in signal level represents the guard bar.

Figure 1 shows a block diagram of parts of the circuitry in a bar code reader embodying the present invention.

In Fig. 1, numeral 1 denotes a bar code to be read, 4 a detector having a photoelectric converter for converting reflected light from the bar code 1 into an electric signal, 6 a binary circuit, 7 a lower limiter, a demodulator, and 13 a start margin recognizing portion. The binary circuit 6 includes an amplitude increase detector 9 for detecting a first black bar after a white margin of the bar code 1.

In Fig. 1, the bar code 1 reflects light when scanned. The detector 4 converts the reflected light into an electric signall which transfers to the binary circuit 6, lower limiter 7, and amplitude increase detector 9.

Suppoting the white margin of the bar code 1 produces no noise, the binary circuit 6 produces a binary signal based on the electric signal, and the demodulator demodulates the binary signal into numerals. At this time, the start margin recognizing portion 13 provides a check bar code. If the white margin is normal, the start margin recognizing portion 13 provides a check result. If other parts of the bar code are also normal, an effectiveness determining circuit 11 judges that the numerals decoded by the demodulator 10 are effective, and transfers them to a computer means (not shown).

If the white margin of the bar code 1 produces noise, the width of the white margin will be measured shorter than a prescribed width, so that the start margin recognizing portion 13 may not provide a start margin recognized signal, and the effectiveness determining circuit 11 does not send the numerals decoded by the demodulator 10.

Namely, if the white margin produces noise, a bar width counter (refer to the counter 173 of Fig. 7) suspends counting of the width of the white bar and restarts the counting after the noise disappears. As a result, the width of the white bar will be

shorter than a normal width.

In the Figure 1 reader, the amplitude increase detector 9 provides a signal after detecting a first black bar after the white margin. This signal is processed in the same way as the signal provided by the start margin recognizing portion 13, and if other parts of the bar code are normal, the effectiveness determining circuit 11 validates the numerals decoded by the demodulator 10.

In this way, even if the white margin produces noise, the Fig. 1 reader uses a signal provided by the amplitude increase detector 9 to validate a signal produced by the black bar that follows the white margin. Accordingly, the Fig. 1 reader can reduce a slice (input threshold) level and correctly read a bar code even with a weak input signal.

An embodiment of the present invention will be explained with reference to Figs. 2A, 2B-1 and 2B-2 and 3.

In Fig 2A , numeral 1 denotes a bar code to be read, 2 a scanning portion for scanning the bar code 1 with a laser beam; 3 a collector for collecting reflected light from the bar code 1, 4 a detector having a photoelectric converter for converting an optical signal into an electric signal, 5 an amplifying portion incorporating an amplifier 5-1 shown in Fig.2B-1 , and 6 a binary circuit. The binary circuit 6 includes a lower limiter 7-1 and an amplitude increase detector 9. The lower limiter 7-1 corresponds to the lower limiter 172 of Fig. 7 but has a lower limit level smaller than that of the lower limiter 172, thereby widening a dynamic range to provide binary data even from a weak signal. In Fig. 2 A , numeral 8 denotes a bar width counter corresponding to the bar width counter 173 of Fig. 7, 10 a demodulating portion corresponding to the demodulating portion 166 of Fig. 7, 11 an effectiveness determining section (167 of Fig. 7) and 12 a bar code construction checking portion corresponding to the bar code construction checking portion 160 of Fig. 7. The portion 12 includes a start margin recognizing portion 13, a guard bar recognizing portion 14, a character recognizing portion 15, and an end margin recognizing portion 16, which correspond to the start margin recognizing portion 161, guard bar recognizing portion 162, character recognizing portion 163, and end margin recognizing portion 164 of Fig. 7, respectively. Also in Fig. 2A , numeral 17 denotes an OR circuit, and 18 a sequence controller corresponding to the sequence controller 165 of Fig. 7. The sequence controller 18 comprises a processor and programs for operating the processor, and provides required functions.

The scanning portion 2 scans the bar code 1. The collector 3 collects reflected light from the scanned bar code 1, and the detector 4 converts the collected light into an electric signal. The amplifying portion 5 amplifies the signal, which is transferred to the binary circuit 6, lower limiter 7-1, and amplitude increase detector 9.

Supposing a white margin of the bar code 1 produces no noise, the binary circuit 6 produces a binary signal from the electric signal, and the bar width counter 8 measures the widths of white and black bars of the bar code 1 according to the binary signal. The demodulating portion 10 demodulates the widths into numerals. A format of the bar code 1 is checked by the start margin recognizing portion 13, guard bar recognizing portion 14, character recognizing portion 15, and end margin recognizing portion 16 of the bar code construction checking portion 12. If the bar code format is normal, the bar code construction checking portion 12 provides a check result, and the sequence controller 18 recognizes that the bar code format is normal. The sequence controller 18 then provides an effective signal to the effectiveness determining section 11. The section 11 then provides as demodulated data the numerals decoded by the demodulating portion 10.

If the white margin of the bar code 1 produces noise, the width of the white margin will be measured shorter than a prescribed width, so that the start margin recognizing portion 13 may not provide a start margin recognized signal, so that in the Fig. 7 reader the sequence controller 165 (18) fails to provide the effective signal.

In the Fig. 2 reader, however, the amplitude increase detector 9 provides, upon detecting after the white margin an input signal whose level steeply increases above a predetermined level, a signal indicating that a first black bar was detected after the white margin. The signal from the detector 9 passes through the OR circuit 17 and reaches the sequence controller 18. The sequence controller 18 treats this signal to be the same as the signal provided by the start margin recognizing portion 13, and provides the effective signal to the effectiveness determining section 11, if other parts of the bar code are normal.

In this way, even if the white margin of the bar code 1 produces noise, it is possible to lower a slice level of the lower limiter 7-2 to read a bar code with a weak input signal.

Figure 28 is a detailed view showing the binary circuit 6 of Fig. 2A and its periphery, and Fig. 3 shows an operation of the Figure 2 circuitry.

In Fig. 2B , the same reference numerals as those of other drawings represent like parts.

In Fig. 2B , numeral 5-1 denotes an amplifier, 5-2 a differential circuit corresponding to the differential circuit 132 of Fig. 5, 6-1 an integrating circuit, and 6-2 a comparator. The comparator 6-2 compares a differentiated signal from the differential circuit 5-2 with an integrated signal from the

integrating circuit 6-1, and provides a differential peak signal PKS shown in Fig. 3(I) corresponding to the signal of Fig. 6(D). In Fig. 3(I), crossed lines indicate areas where noise occurs. In these areas, an output signal level fluctuates between ON and OFF states.

A DC level portion 6-3 has resistors 63a and 63b, a capacitor 63c, and an impedance converting amplifier 63d, and determines an intermediate point of an output voltage of the differential circuit 5-2. A gate portion 6-4 is similar to that of Fig. 5 and provides a binary signal BCD, which is transferred to the bar width counter 8 for measuring the widths of black and white bars of a bar code.

The lower limiter 7-1 comprises resistors 71a to 71c, a variable resistor 71d between a power source of -12 V and ground, an addition amplifier 71e, and a diode 71f, and maintains a peak hold signal discharge waveform PKH above a predetermined lower limit value. With the lower limiter 7-1, the peak hold signal discharge waveform PKH provided by a peak holding portion 20 will never be below the lower limit level as shown in the left side of Fig. 3(C). The peak holding portion 20 comprises a diode 20a, a resistor 20b, and a capacitor 20c.

A differential circuit 9-1, a detection value setting portion 9-2, and a comparator 9-3 form the amplitude increase detector 9. The detection value setting portion 9-2 has a variable resistor 92a disposed between a DC power source 92b and ground. The differential circuit 9-1 differentiates the peak hold signal discharge waveform PKH provided by the lower limiter 7-1, and provides a differentiated PKH signal shown in Fig. 3(D). The comparator 9-3 compares the differentiated PKH signal with a threshold Th0 provided by the detection value setting portion 9-2. The threshold Th0 is a voltage of an armature 92c of the variable resistor 92a. If the differentiated PKH signal is greater than the threshold Th0, the comparator 9-3 provides a detected signal P to the OR circuit 17 of Fig. 2A . A discharging portion 21 has a resistor 21a and discharges an output of the peak holding portion 20.

As shown in Fig. 3(D), when a first black bar b1 is detected, a change in the peak hold signal discharge wavef orm PKH reaches the maximum, and when a second black bar b2 is detected, a change in the peak hold signal discharge waveform PKH is smaller that the maximum. The reason of this is because the discharge waveform PKH is held in the peak holding portion 20 and because the discharge attenuation quantity of the discharging portion 21 is small in a short time period such as in a scanning period of an interval of the black bars.

The peak holding portion 20 holds a peak value of an output signal D of the differential circuit 5-2.

A voltage dividing portion 22 has resistors 22a and 22b having resistance values of 100 KΩ and 50 KΩ respectively, and an amplifier 22c. The voltage dividing portion 22 divides an output of the lower limiter 7-1 into, for example, -1/2 to produce a white bar slice level WTh, which is supplied to an inverting portion 23. The inverting portion 23 produces a black bar slice level BTh. The voltage dividing ratio may be chosen according to requirements. The inverting portion 23 has resistors 23a and 23b each having a resistance value of 100 KΩ, and an amplifier 23c. The inverting portion 23 provides an output voltage of -1 times the voltage supplied to the amplifier 23c. The black bar slice level BTh and white bar slice level WTh are provided to comparators 24 and 25, respectively, and compared with the output signal D of the differential circuit 5-2. Tthe comparators 24 and 25 then provide gate signals BLK and WHT, respectively, to the gate portion 6-4.

Figure 3(C) shows the black bar slice level BTh and white bar slice level WTh with dash-and-dot lines. Figure 3(F) shows the gate signal BLX provided by the comparator 24, and Fig. 3(H) shows the gate signal WHT provided by the comparator 25.

According to the differential peak signal PKS provided by the comparator 6-2 and the gate signals BLK and WHT, the gate portion 6-4 provides a black edge signal BEG shown in Fig. 3(J) and a white edge signal WEG shown in Fig. 3(K). Based on these signals, a binary signal BCD of Fig. 3(L) is formed.

In the example of Fig. 3, the white margin before the black bar b1 produces noise N due to, for example, irregularities on the surface of a sheet where the bar code is printed. The noise N produces noise N′ in the binary signal BCD. The start margin recognizing portion 13 of Fig. 1, therefore, does not provide a white margin recognized signal. At the end of the white margin, i.e., at a leading edge of the black bar b1, the comparator 9-3 of the amplitude increase detector 9 provides the signal P of Fig. 3(E) to the OR circuit 17, which provides the signal P to the sequence controller 18. The detection signal P indicates that a signal level has steeply increased. According to the signal P, the sequence controller 18 of Fig. 2A judges that the start margin recognizing portion 13 has provided an output, and provides an effective signal, if other parts of the bar code are normal. As a result, even with such noise, the effectiveness determining portion 11 provides demodulated data, i.e., numerals decoded by the demodulating portion

Figure 4 shows a second embodiment of the present invention.

Instead of the bar width counter 8 of Fig. 2A , the embodiment of Fig. 4 employs a bar width

counter 8 having a margin width correcting circuit. Except the OR circuit 17, the arrangement of Fig. 4 is the same as that of Figs. 2 A and 2B . In Fig. 4 numeral 8-1 denotes a white bar counter for measuring the width of a white bar, and 8-2 a white bar register. Numeral 8-3 denotes a black bar counter for measuring the width of a black bar, 8-4 a black bar register for storing a count of the black bar counter 8-3, 8-5 a-clock oscillator oscillating at, for example, 40 MHz for driving the white bar counter 8-1 and black bgr counter 8-3, and 8-6 an inverter for inverting the binary signal BCD to provide an enabling signal for the black bar counter 8-3. An enabling signal for the white bar counter 8-1 is the binary signal BCD.

In Fig. 4, the white bar register 8-2 is set with a count of the white bar counter 8-1 under a normal state. If the comparator 9-3 of Fig. 2B provides the detection signal P of Fig. 3(E), the white bar register 8-2 is preset to, for example, all 1s. Namely, the count of the counter 8-1 is rewritten with a maximum value, and it is judged that, even if noise occurs, there is a white bar of predetermined width.

One concrete example will be explained. It is supposed that the scanning of a normal start margin provides a count of 3000 in the white bar register 8-2. If noise occurs during the scanning, the counting operation suspends, and restarts after the noise disappears. It is supposed that the white bar register 8-2 is showing a count of 300 when the next black bar, i.e., a guard bar has been detected. Rather than regard this value as one that does not represent the start margin of a bar code, in the Figure 4 embodiment the detected signal P is applied, when the guard bar is detected, to the white bar register 8-2 that is showing 300, thereby rewriting the count to 3000 and changing the status as if there is a normal start margin.

In this way, the signal P is provided when the first black bar b1 is detected after the white margin of the bar code, and the white bar register 8-2 is preset to all 1s of a predetermined value. Thereafter, the start margin recognizing portion 13 of Fig. 2A reads the white bar register 8-2 and judges that there is a white margin having a predetermined width and provides a recognized signal to the sequence controller 18. The sequence controller 18 then recognizes that there is the start white margin having the predetermined width.

The embodiment of Fig. 4 does not require the OR circuit 17 of Fig. 2A , and an output of the start margin recognizing portion 13 is directly transferred to the sequence controller 18.

In this way, embodiments of the invention utilize the fact that there is a large difference between the amplitude of noise produced by irregularities on a white margin of a bar code and the amplitude of a signal produced by a start portion (guard bar) of the bar code, and recognize that the guard bar after the white margin of the bar code is being scanned if the amplitude of a signal steeply changes.

By detecting the steep change in the signal amplitude, it is possible to find the start of the bar code, even if very small irregularities on the white margin of the bar code produce noise.

As a result, it is possible to set a lower limit value of a signal amplitude lower than that of the Figure 5 reader , thereby securing a larger dynamic range.

The signal amplitude may steeply increase due to regular reflection from a scanned medium or disturbing light such as lighting and sunlight. It is possible to discriminate a signal produced by such disturbance from a bar code signal according to a signal pattern following the disturbance signal, so that no malfunction may occur due to the disturbance.

Thus, a bar code reader embodying the present invention can correctly recognize the start ofa bar code even with a relatively small lower limit value, thereby affording a desirably wide dynamic range and facilitating an improvement in the reading performance of the reader.

Claims

1. A bar code reading system comprising:
a scanning portion;
a collector for collecting light reflected by a bar code;
a binary circuit for producing a binary signal according to an analog signal extracted from the collected light;
a bar width counter for computing the widths of bars of the bar code according to an output of said binary circuit;
a demodulating portion for providing data according to the widths computed by said bar width counter;
a bar code construction checking portion for checking the construction of predetermined parts of the bar code according to the widths computed by said bar width counter; and
a sequence controller for controlling said bar code construction checking portion, said sequence controller judging that the data provided by said demodulating portion are effective only when the bar code is judged to have a predetermined construction, and allowing the data to be supplied outside; and characterizing in that said bar code reading system is provided with an amplitude increase detecting means for detecting when the amplitude of the analog signal steeply changes,
said sequence controller ignoring noise produced

by at least a start margin of the bar code when said amplitude increase detecting means provides a detected signal, and carrying out its controlling task as if the start margin of the bar code is normal.

2. A bar code reading system as set forth in claim 1, wherein, when said bar code construction checking portion detects that at least the start margin has produced noise and when said amplitude increase detecting means detects that the amplitude of an analog signal corresponding to a guard bar disposed after the start margin of the bar code has steeply changed to exceed a predetermined value, said sequence controller ignores the noise produced by the start margin and judges that the start margin is normal.

3. A bar code reading apparatus having:

a scanning portion;

a collector for collecting light reflected by a bar code;

a binary circuit for producing a binary signal according to an analog signal extracted from the collected light;

a bar width counter for computing the widths of bars of the bar code according to an output of said binary circuit;

a demodulating portion for providing data according to the widths computed by said bar width counter;

a bar code construction checking portion for checking the construction of predetermined parts of the b bar code according to the widths computed by said bar width counter; and

a sequence controller for controlling said bar code construction checking portion, said sequence controller judging that the data provided by said demodulating portion are effective only when the bar code is judged to have a predetermined construction, and allowing the data to be supplied outside, and said bar code reading apparatus is characterized in that said bar code construction checking portion at least comprises a start margin recognizing portion, a guard bar recognizing portion, and a character recognizing portion, outputs of these recognizing portions being separately connected to said sequence controller, an input of said start margin recognizing portion being connected to an output of said bar width counter, an output of said start margin recognizing portion being connected to said sequence controller through an OR circuit whose one input is connected to an output of an amplitude increase detecting means.

4. A bar code reading system as set forth in claim 1, wherein said bar width counter has a white bar counter, a white bar register for said white bar counter, a black bar counter, and a black bar register for said black bar counter, said counters accumulating their counts in said corresponding registers according to information provided by said binary circuit, the count of at least said white bar counter being rewritten to a count that is obtainable when there is a normal white bar in the bar code, according to an output signal of said amplitude increase detecting means.

5. A bar code reading system as set forth in claim 4, wherein, when the count stored in said white bar register is smaller than a count that is obtainable when there is a normal start margin in the bar code, due to noise produced by at least the start margin, and when the amplitude of an analog signal corresponding to a guard bar that follows just after the start margin of the bar code steeply changes to exceed a predetermined value, the count stored in said white bar register is rewritten, according to a detected signal provided by said amplitude increase detecting means, to one equal to or above a count that is obtainable when there is a normal start margin in the bar code.

6. A bar code reading apparatus having:

a scanning portion;

a collector for collecting light reflected by a bar code;

a binary circuit for producing a binary signal according to an analog signal extracted from the collected light;

a bar width counter for computing the widths of bars of the bar code according to an output of said binary circuit;

a demodulating portion for providing data according to the widths computed by said bar width counter;

a bar code construction checking portion for checking the construction of predetermined parts of the bar code according to the widths computed by said bar width counter; and

a sequence controller for controlling said bar code construction checking portion, said sequence controller judging that the data provided by said demodulating portion are effective only when the bar code is judged to have a predetermined construction, and allowing the data to be supplied outside, and said bar code reading apparatus is characterized in that said bar width counter comprises a white bar counter, a white bar register for said white bar counter, a black bar counter, and a black bar register for said black bar counter, an output of an amplitude increase detecting means being connected to a preset terminal of said white bar register so that the count of said white bar counter may be updated to a predetermined value according to the output of said amplitude increase detecting means.

Fig. 1

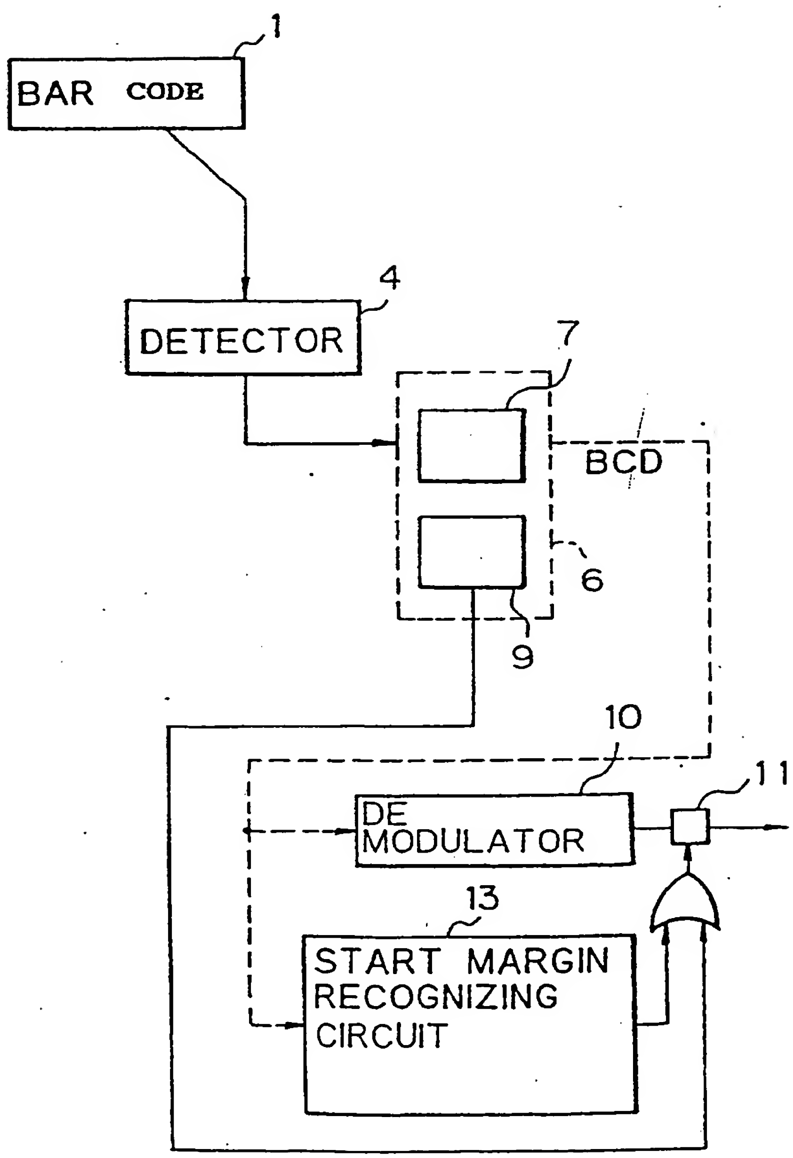
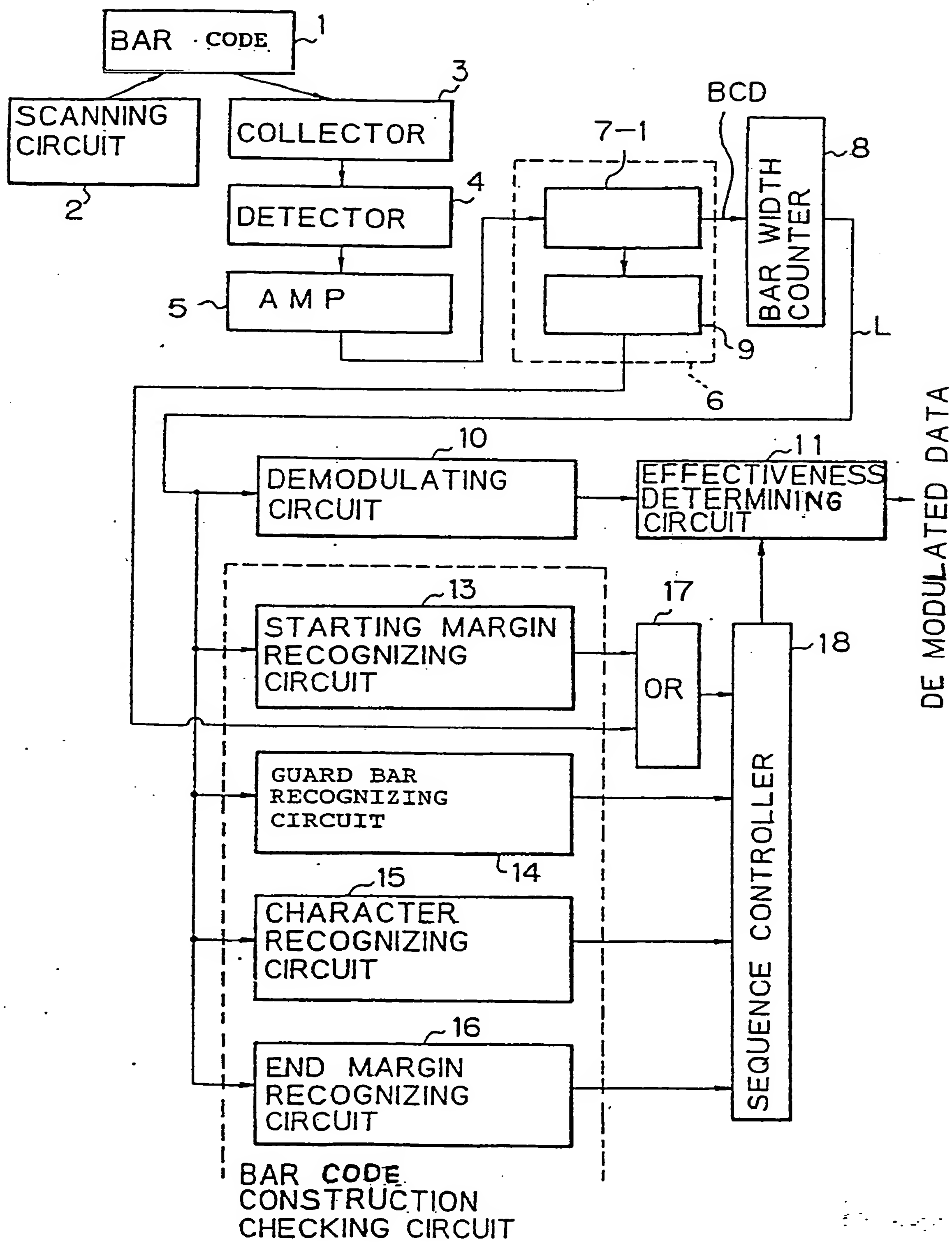

1
BAR CODE
4
DETECTOR
7
BCD
6
9
10
11
DE MODULATOR
13
START MARGIN RECOGNIZING CIRCUIT

Fig. 2A



BAR CODE
1
SCANNING CIRCUIT
2
COLLECTOR
3
DETECTOR
4
AMP
5
BCD
7-1
BAR WIDTH COUNTER
8
9
6
L
10
DEMODULATING CIRCUIT
11
EFFECTIVENESS DETERMINING CIRCUIT
DE MODULATED DATA
13
STARTING MARGIN RECOGNIZING CIRCUIT
17
OR
18
SEQUENCE CONTROLLER
GUARD BAR RECOGNIZING CIRCUIT
14
15
CHARACTER RECOGNIZING CIRCUIT
16
END MARGIN RECOGNIZING CIRCUIT
BAR CODE CONSTRUCTION CHECKING CIRCUIT

Fig. 2B

Fig. 2B−1	Fig.2B−2

F I g. 2B−1

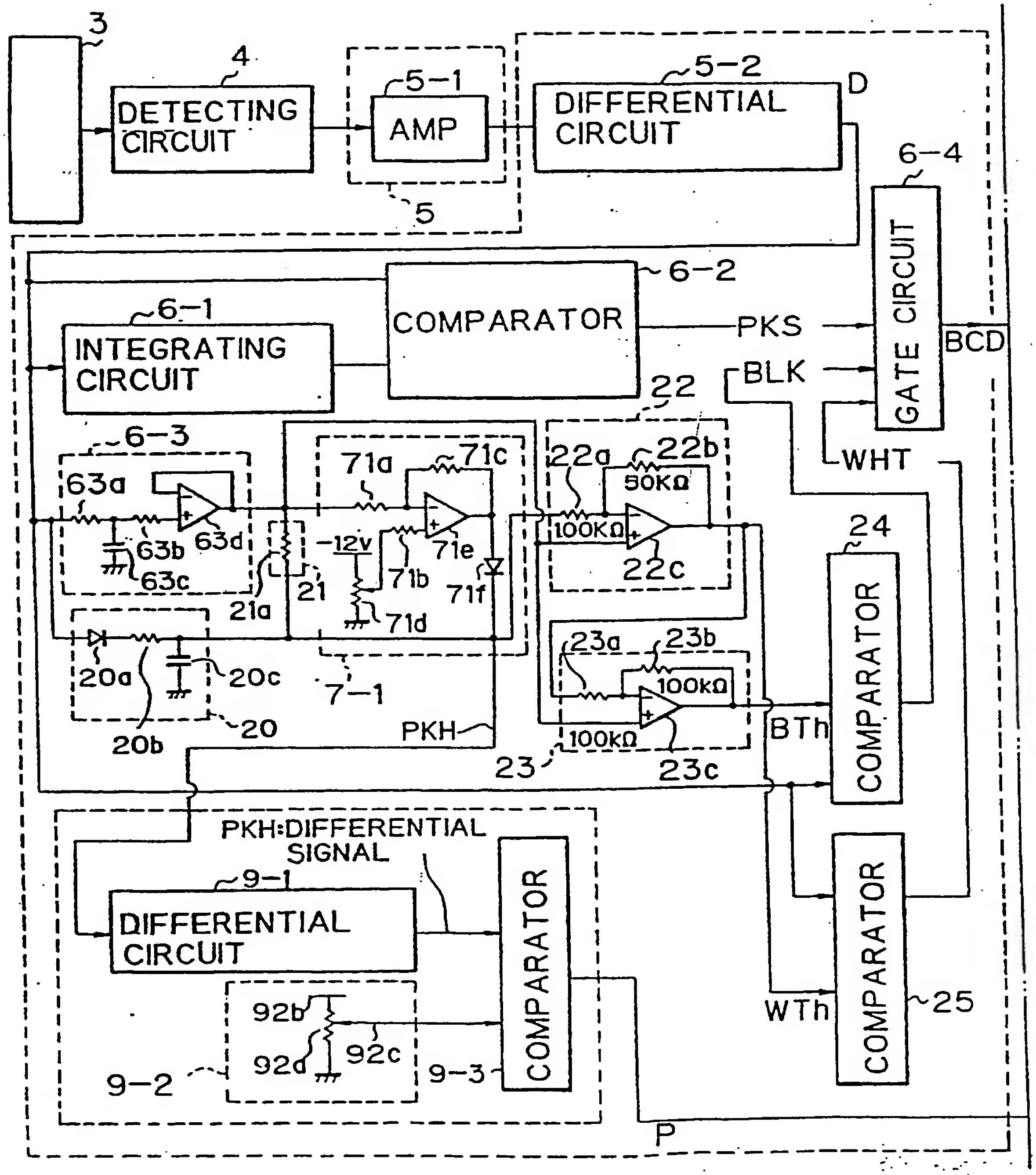
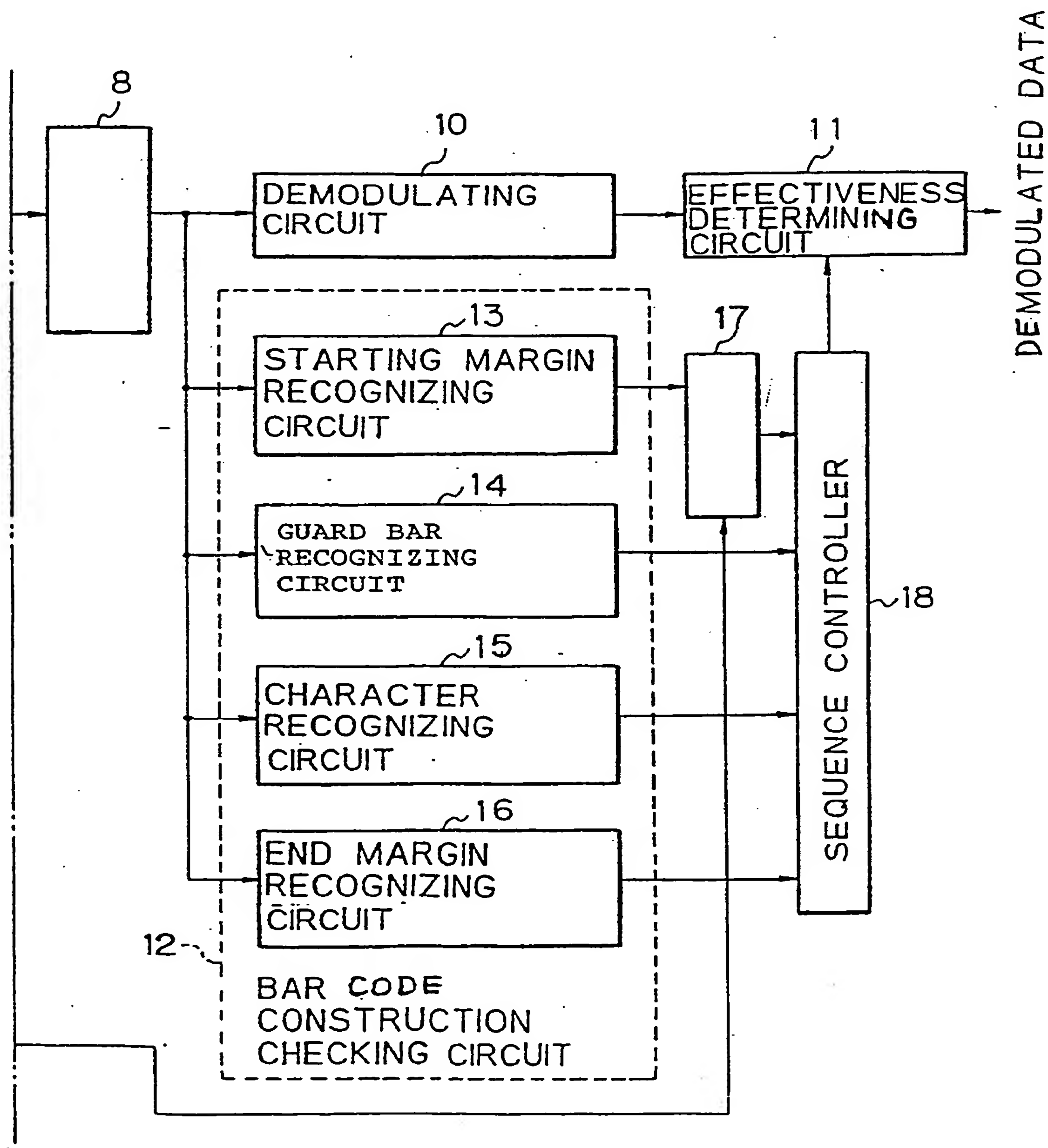


Fig. 2B-2


8
10
DEMODULATING CIRCUIT
11
EFFECTIVENESS DETERMINING CIRCUIT
DEMODULATED DATA
13
STARTING MARGIN RECOGNIZING CIRCUIT
17
14
GUARD BAR RECOGNIZING CIRCUIT
18
SEQUENCE CONTROLLER
15
CHARACTER RECOGNIZING CIRCUIT
16
END MARGIN RECOGNIZING CIRCUIT
12
BAR CODE CONSTRUCTION CHECKING CIRCUIT

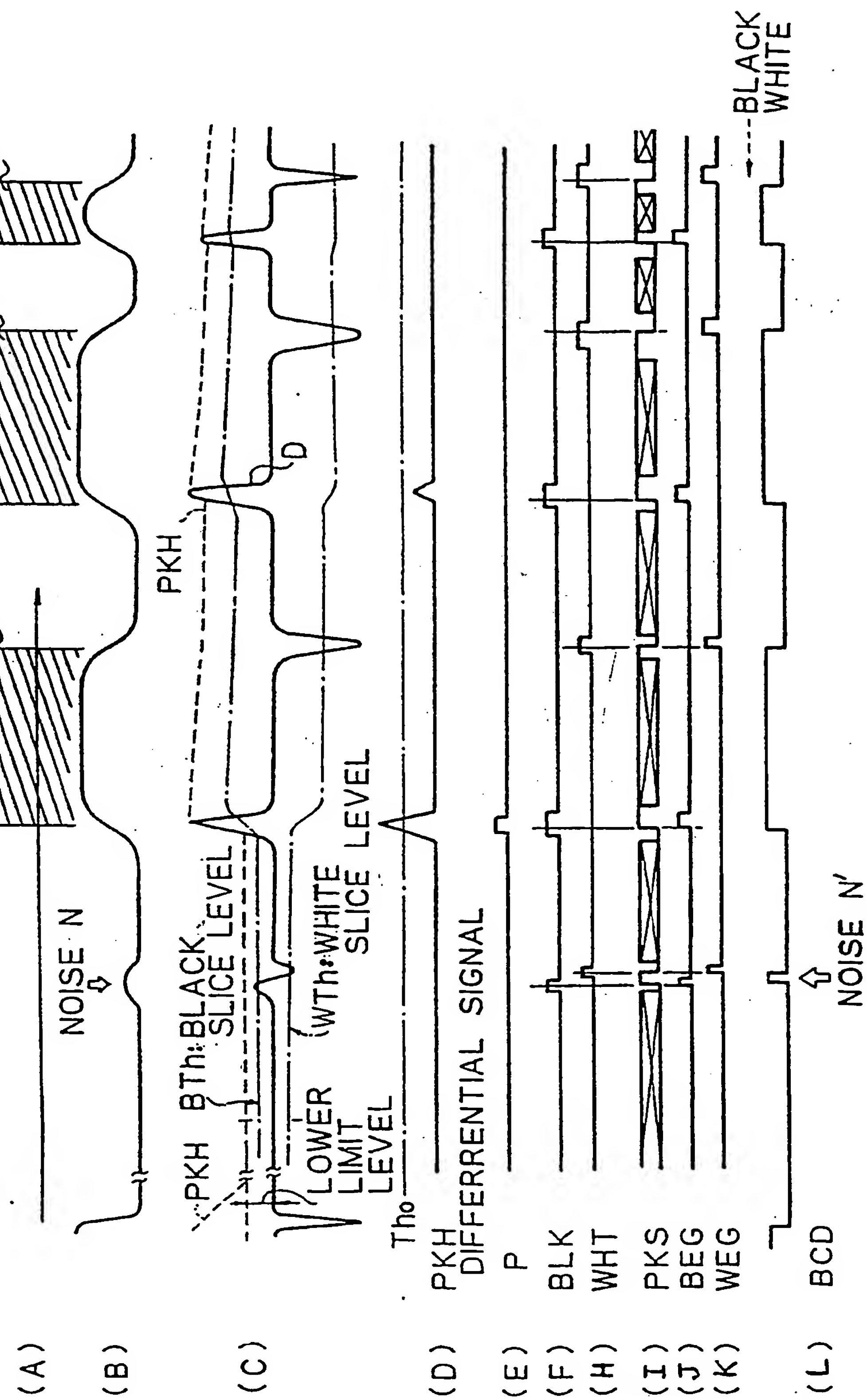

(A)
(B)
(C)
(D)
(E)
(F)
(H)
(I)
(J)
(K)
(L)
NOISE N
b1
b2
b3
PKH
BTh: BLACK SLICE LEVEL
D
LOWER LIMIT LEVEL
WTh: WHITE SLICE LEVEL
Tho
PKH DIFFERENTIAL SIGNAL
P
BLK
WHT
PKS
BEG
WEG
BCD
NOISE N'
BLACK
WHITE

Fig. 3

Fig. 4A

Fig. 4

Fig. 4A	Fig. 4B	Fig. 4C

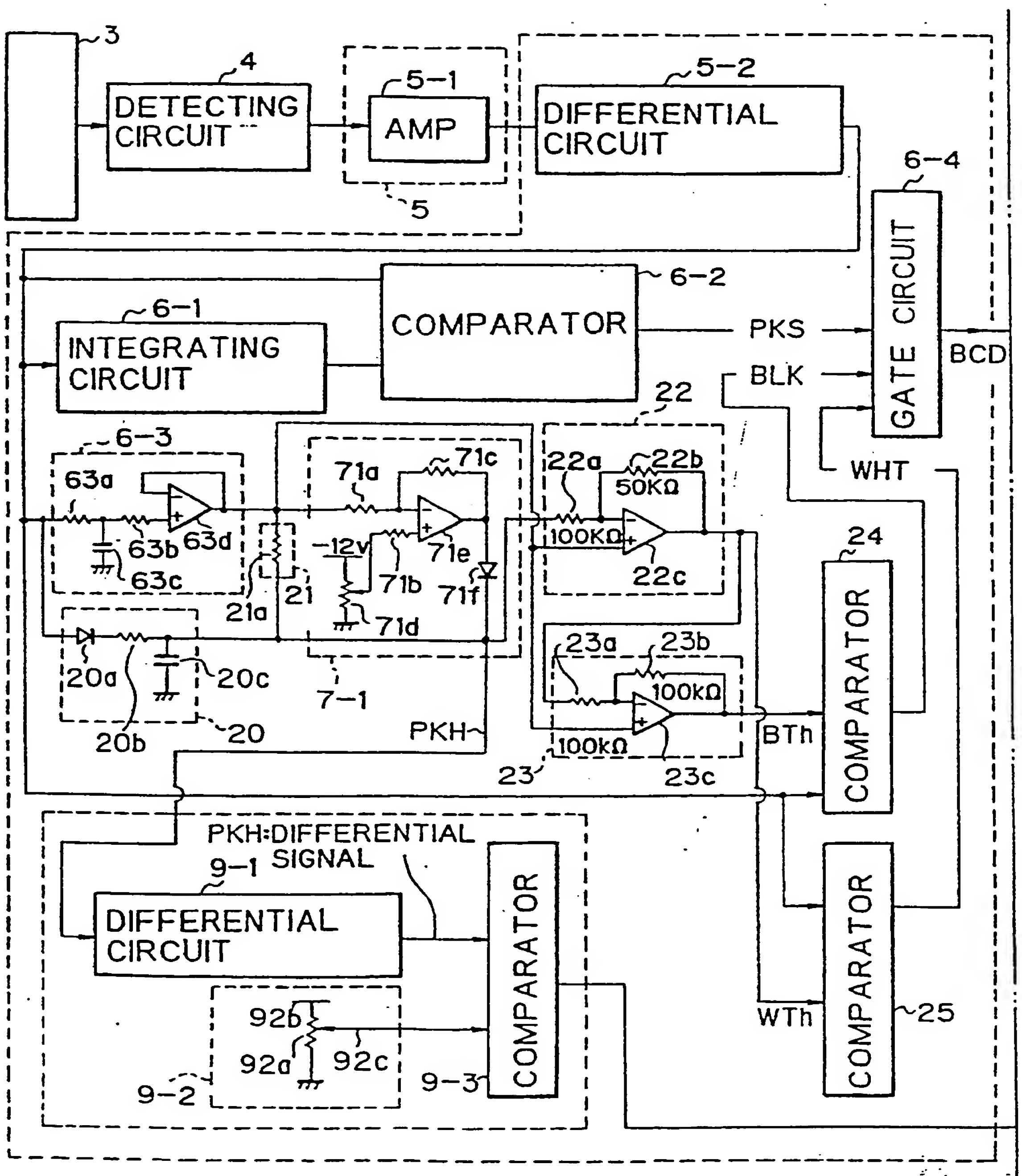


FIg. 4B

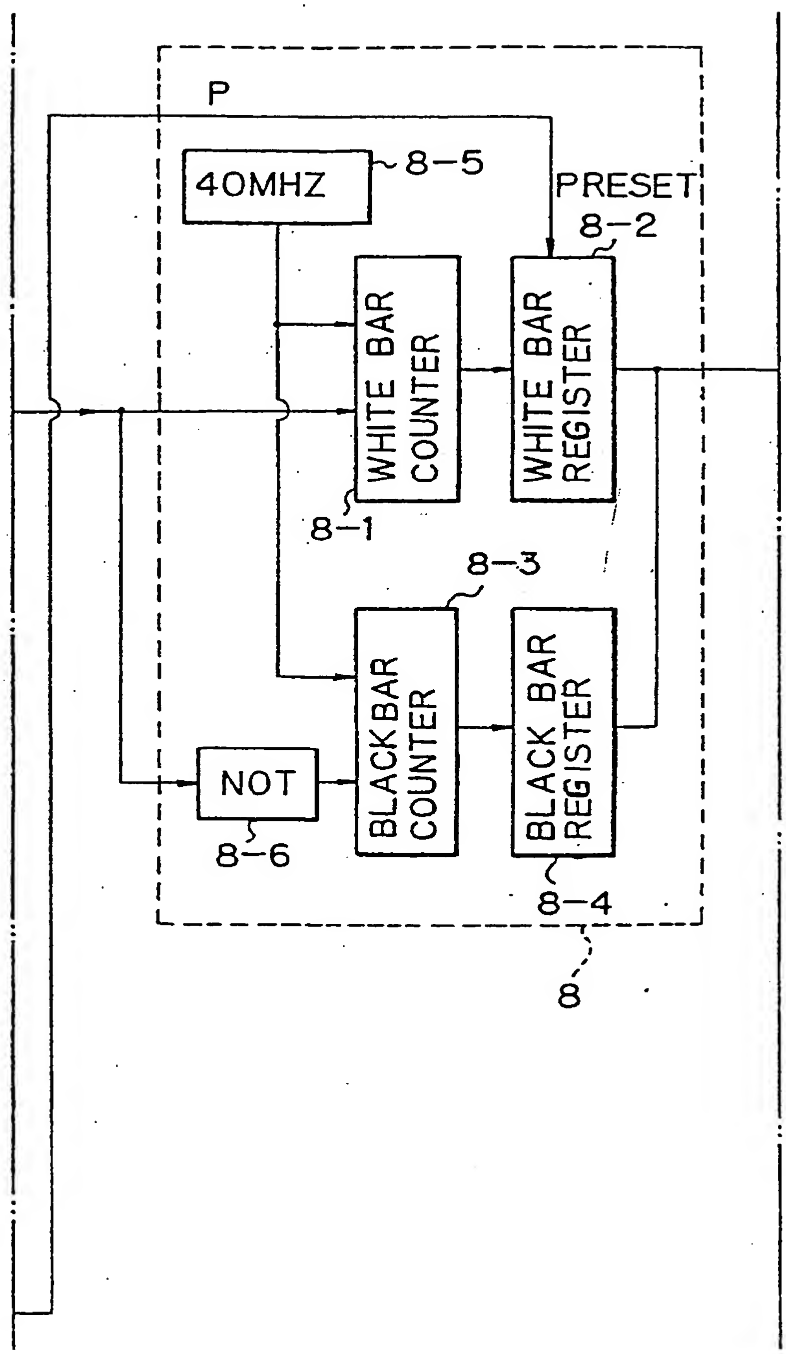

P
40MHZ
8-5
PRESET
8-2
WHITE BAR COUNTER
WHITE BAR REGISTER
8-1
8-3
BLACK BAR COUNTER
BLACK BAR REGISTER
NOT
8-6
8-4
8

Fig. 4C

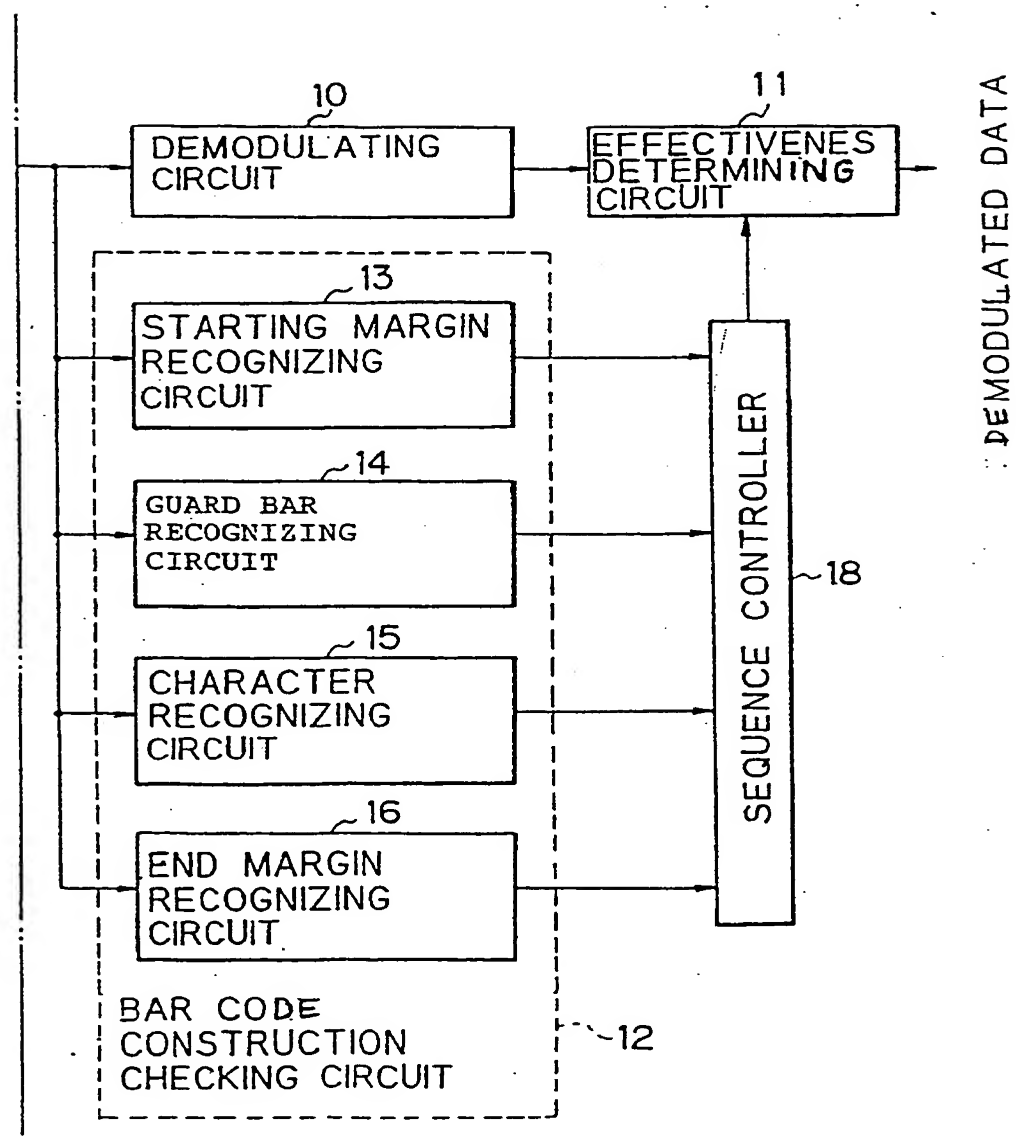

10
DEMODULATING CIRCUIT
11
EFFECTIVENES DETERMINING CIRCUIT
DEMODULATED DATA
13
STARTING MARGIN RECOGNIZING CIRCUIT
14
GUARD BAR RECOGNIZING CIRCUIT
15
CHARACTER RECOGNIZING CIRCUIT
16
END MARGIN RECOGNIZING CIRCUIT
SEQUENCE CONTROLLER
18
BAR CODE CONSTRUCTION CHECKING CIRCUIT
12

Fig. 5A

Fig. 5

Fig. 5A	Fig. 5B

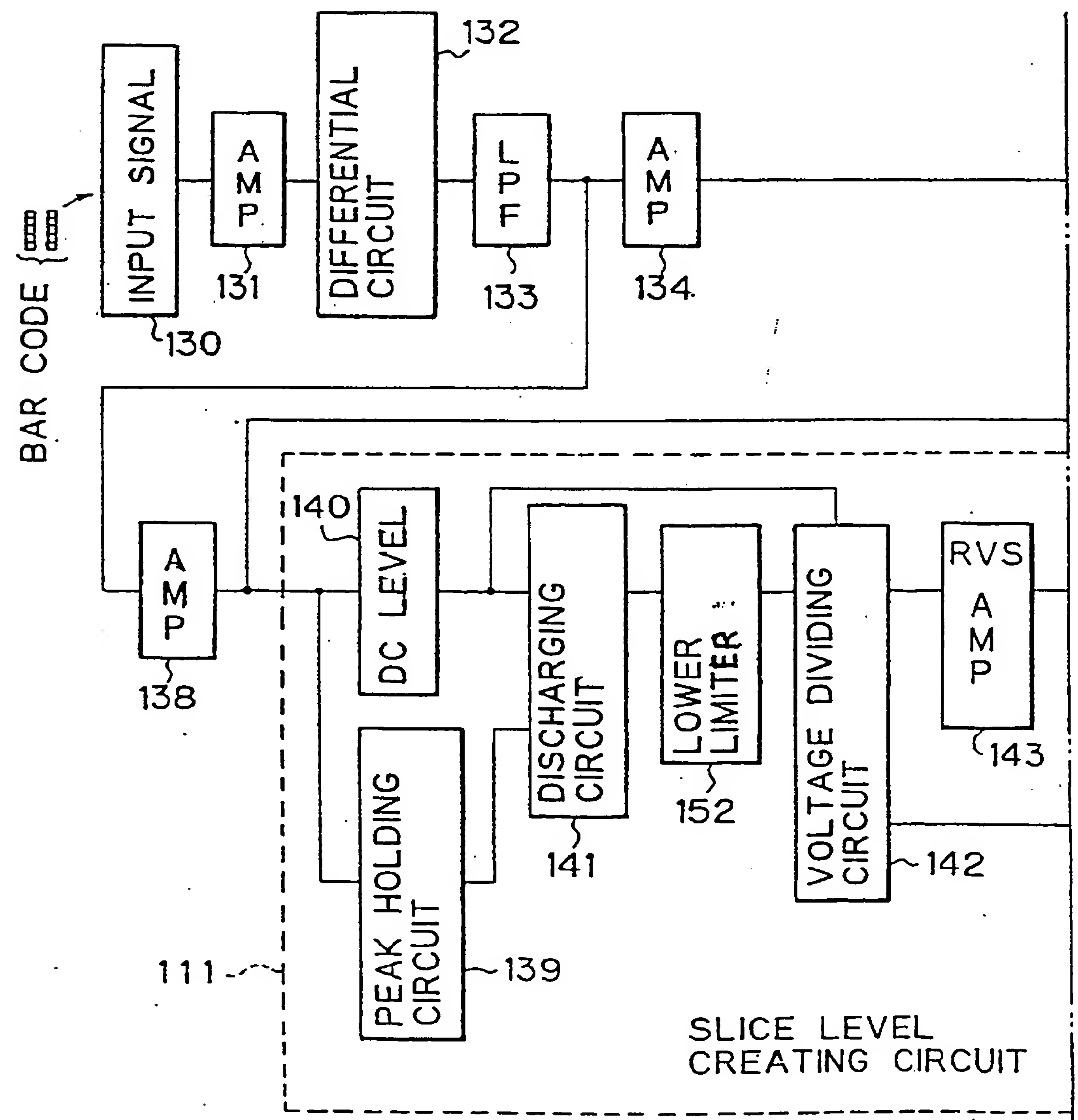


Fig. 5B

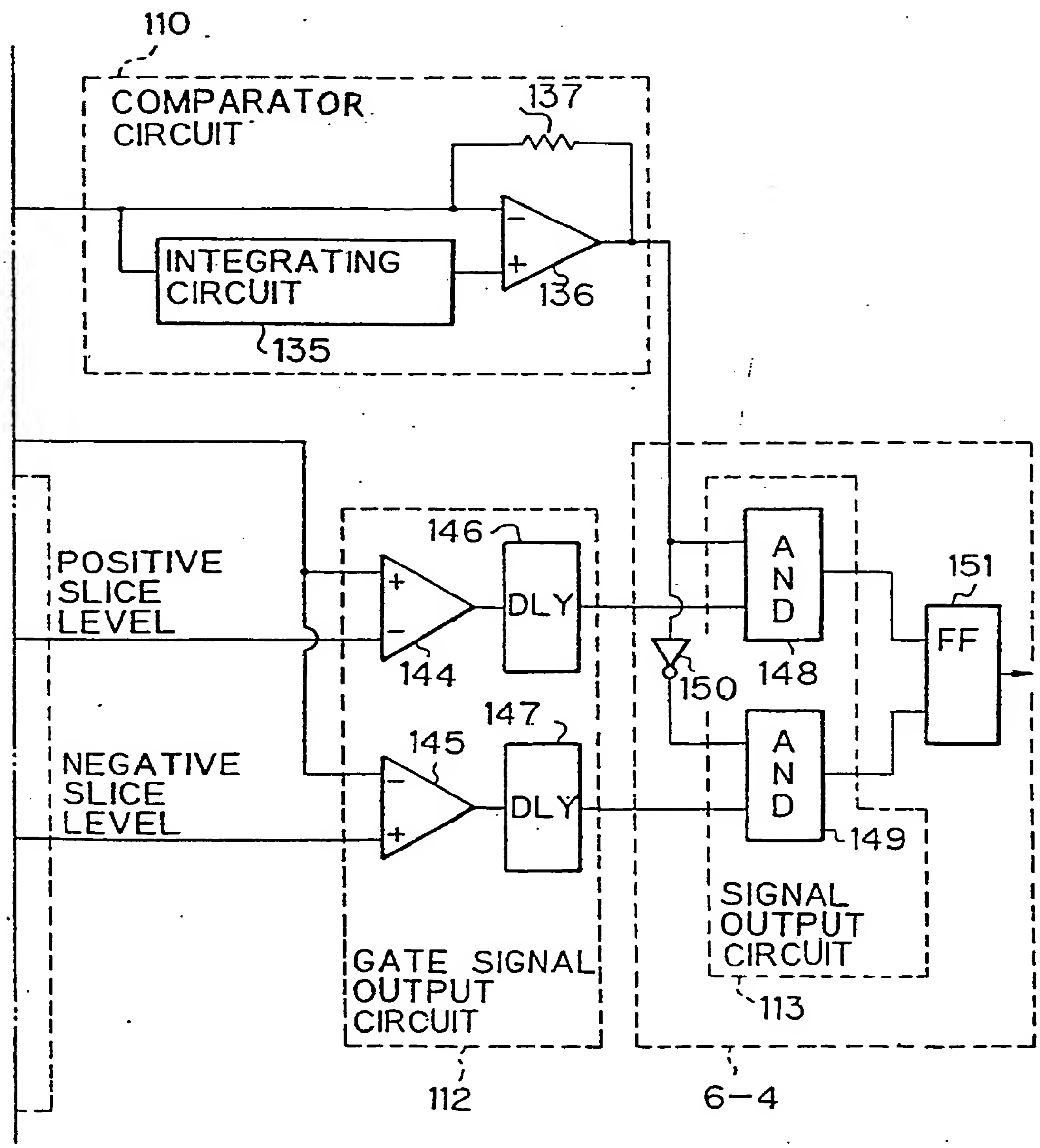

110
COMPARATOR CIRCUIT
137
INTEGRATING CIRCUIT
136
135
POSITIVE SLICE LEVEL
NEGATIVE SLICE LEVEL
146
DLY
144
147
145
DLY
A N D
150
148
151
FF
A N D
149
SIGNAL OUTPUT CIRCUIT
113
GATE SIGNAL OUTPUT CIRCUIT
112
6−4

Fig. 6

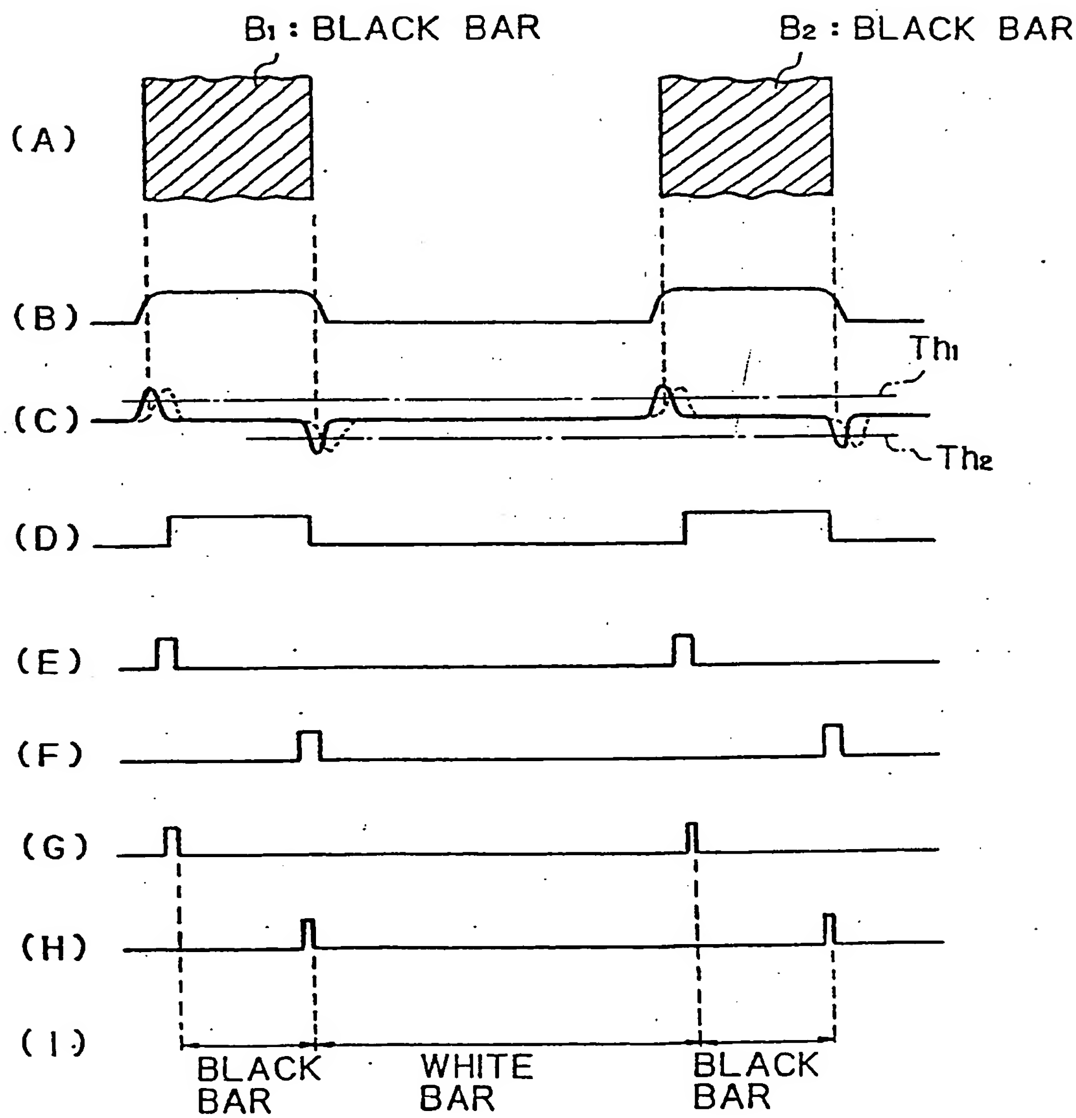
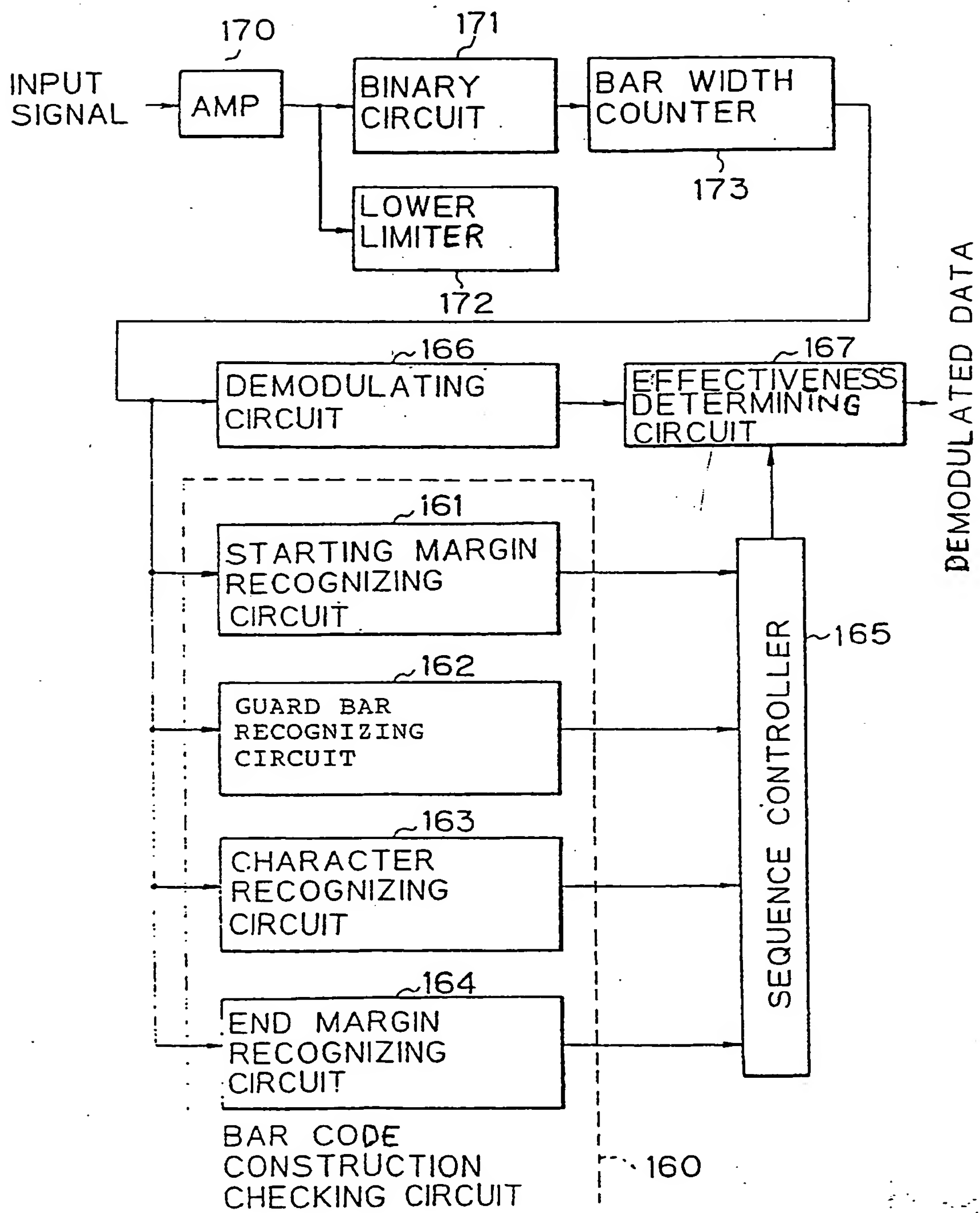

B1 : BLACK BAR
B2 : BLACK BAR
(A)
(B)
Th1
(C)
Th2
(D)
(E)
(F)
(G)
(H)
(I)
BLACK BAR
WHITE BAR
BLACK BAR

Fig. 7



170
171
INPUT SIGNAL
AMP
BINARY CIRCUIT
BAR WIDTH COUNTER
173
LOWER LIMITER
172
166
DEMODULATING CIRCUIT
167
EFFECTIVENESS DETERMINING CIRCUIT
DEMODULATED DATA
161
STARTING MARGIN RECOGNIZING CIRCUIT
162
GUARD BAR RECOGNIZING CIRCUIT
163
CHARACTER RECOGNIZING CIRCUIT
164
END MARGIN RECOGNIZING CIRCUIT
SEQUENCE CONTROLLER
165
BAR CODE CONSTRUCTION CHECKING CIRCUIT
160

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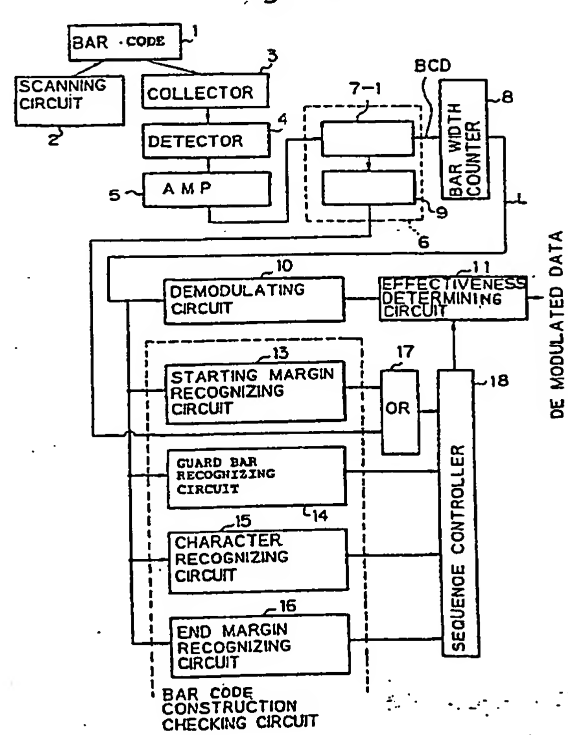
(54) Bar code readers.

(57) A bar code reading system produces a binary signal from an analog signal containing a bar code signal, and derives from the binary signal appropriate bar code data. The bar code reading system comprises an amplitude increase detector (9) for detecting when the amplitude of the analog signal changes steeply, and a sequence controller (18) for controlling an output of a demodulator (10) that demodulates the binary signal to produce the bar code data. When the amplitude increase detector (9) provides a detected signal, indicative of a steep increase in the analog signal, the sequence controller (18) carries out its controlling task as if the bar code has a normal white margin even if the white margin produces noise.

Such a system can correctly recognize the start of the bar code irrespective of noise and can enable a lower limit threshold level, below which the analog signal is effectively ignored, to be lowered, thereby improving dynamic range.

Fig. 2A



EP 0 427 528 A3

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Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 31 2170

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 667 089 (K. SHIRAKABE et al.) * column 1, line 36 - column 3, line 3; cliams 1,4; figures 1,2 *	1,3-6	G 06 K 7/10
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 237 (P-487)(2293), 15 August 1986; & JP - A - 6168675 (TOKYO ELECTRIC CO. LTD.) 09.04.1986	1,3,6	
A	FR-A-2 247 023 (THE YOKOHAMA RUBBER COMP.) * page 1, line 7 - page 2, line 34; claim 1; figures 3a,b *	1,3-6	
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 237 (P-157)(1115), 25 November 1982; & JP - A - 57136280 (FUJITSU K.K.) 23.08.1982	1,3,6	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 06 K 7/10

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
Berlin	10 June 91	DUCREAU F B

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